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(54) **DETERMINING WIRELESS COVERAGE INFORMATION USING WIRELESS ACCESS POINTS**

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H04W 48/10 (2009.01)
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(52) **U.S. Cl.**
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(Continued)

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CPC ... H04W 64/003; H04W 48/10; H04W 16/18; H04W 88/08; H04B 17/318
See application file for complete search history.

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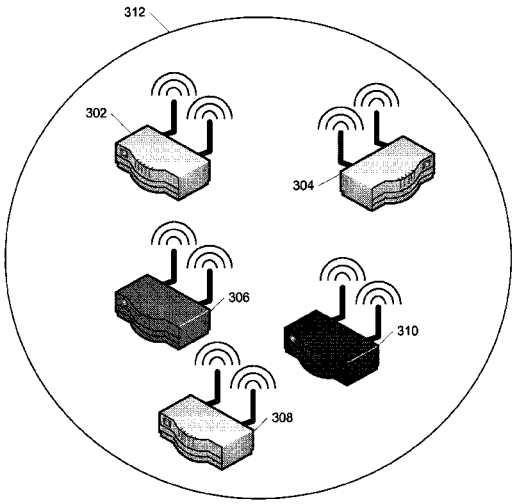
(57) **ABSTRACT**

Aspects of the disclosure relate to various approaches to gathering information about access nodes serving in an area and using the information to generate a coverage map. The coverage map may be generated by detecting broadcasted signal strengths from a plurality of access nodes as detected by other access nodes. The broadcasted signal strengths can be used in combination with the location of the access nodes receiving the broadcasted signal to estimate a location of each of the plurality of access nodes. A coverage map may be generated based on the estimated locations of each of the plurality of access nodes using an effective coverage range for each access node based on the access node type. The coverage of each access node may be refined by analyzing signal data received by neighboring nodes. The coverage map may be used to identify unauthorized devices.

17 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

H04W 40/24	(2009.01)
H04W 16/18	(2009.01)
H04W 88/08	(2009.01)
H04B 17/318	(2015.01)

(52) **U.S. Cl.**

CPC ***H04W 40/246*** (2013.01); ***H04W 48/10*** (2013.01); *H04W 88/08* (2013.01)

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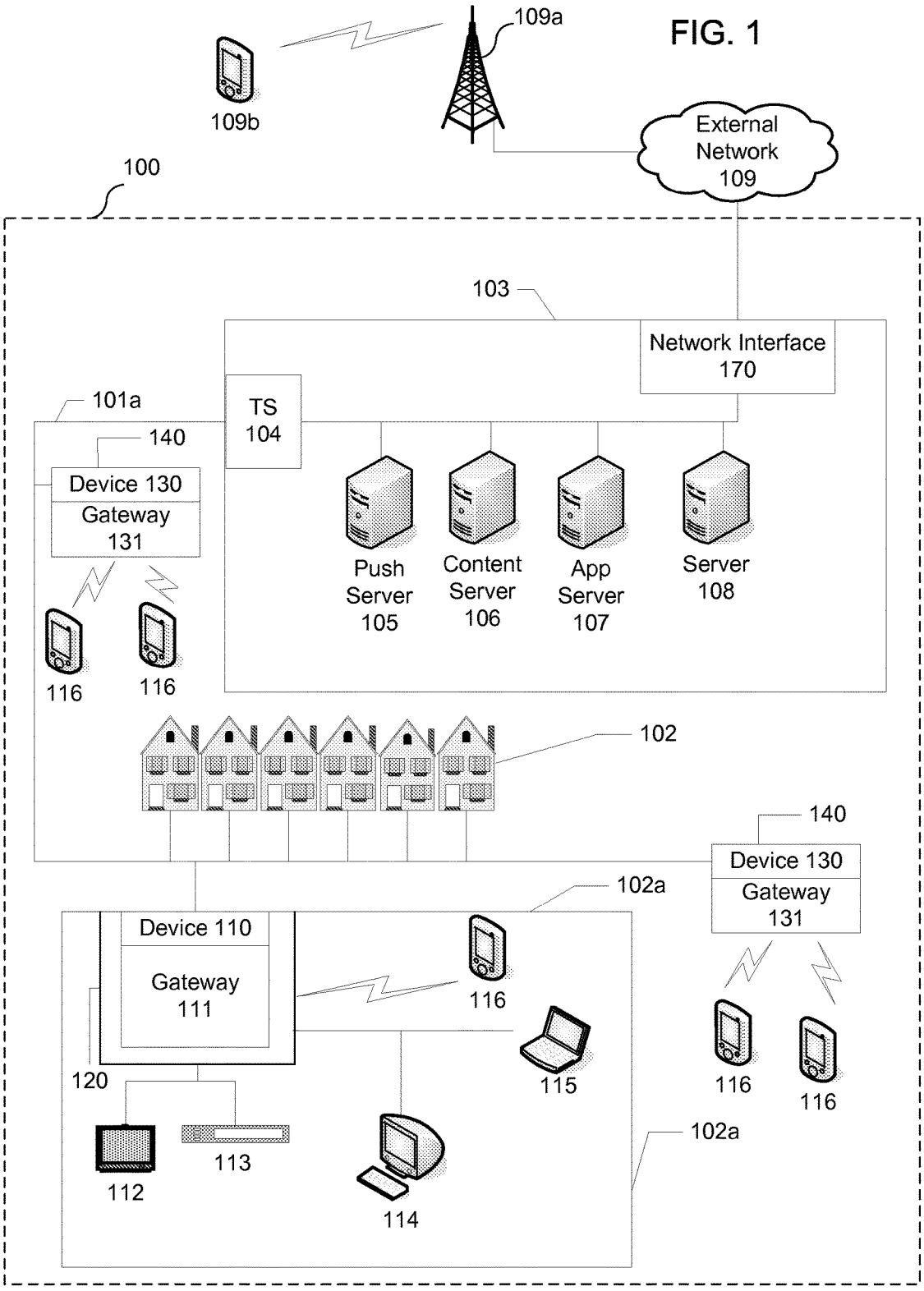
FIG. 1


109a
109b
External Network 109
100
103
Network Interface 170
TS 104
101a
140
Device 130
Gateway 131
Push Server 105
Content Server 106
App Server 107
Server 108
116
116
102
140
Device 130
Gateway 131
102a
Device 110
Gateway 111
116
120
115
116
116
112
113
114
102a

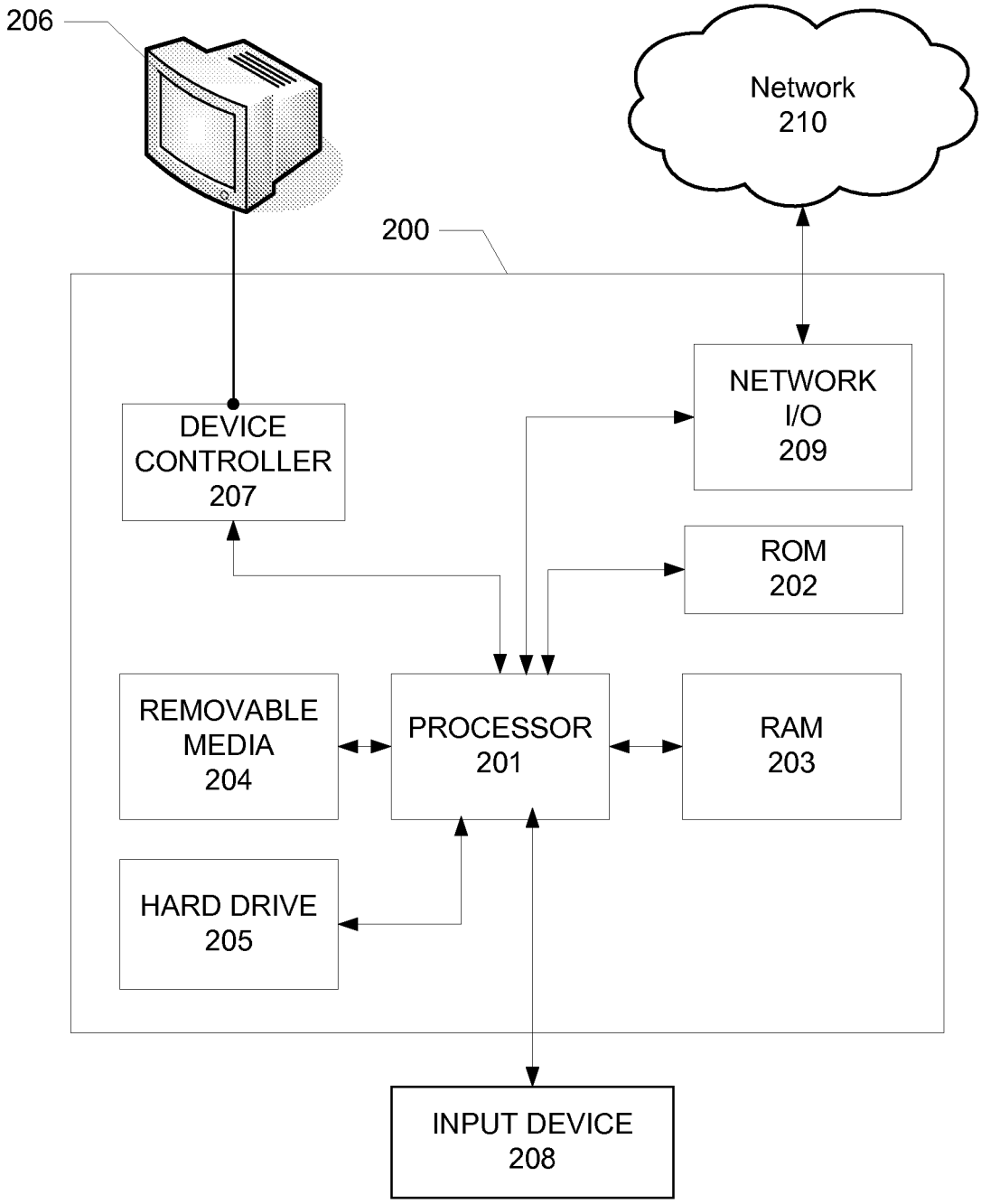

206
Network
210
200
NETWORK
I/O
209
DEVICE
CONTROLLER
207
ROM
202
REMOVABLE
MEDIA
204
PROCESSOR
201
RAM
203
HARD DRIVE
205
INPUT DEVICE
208

FIG. 2

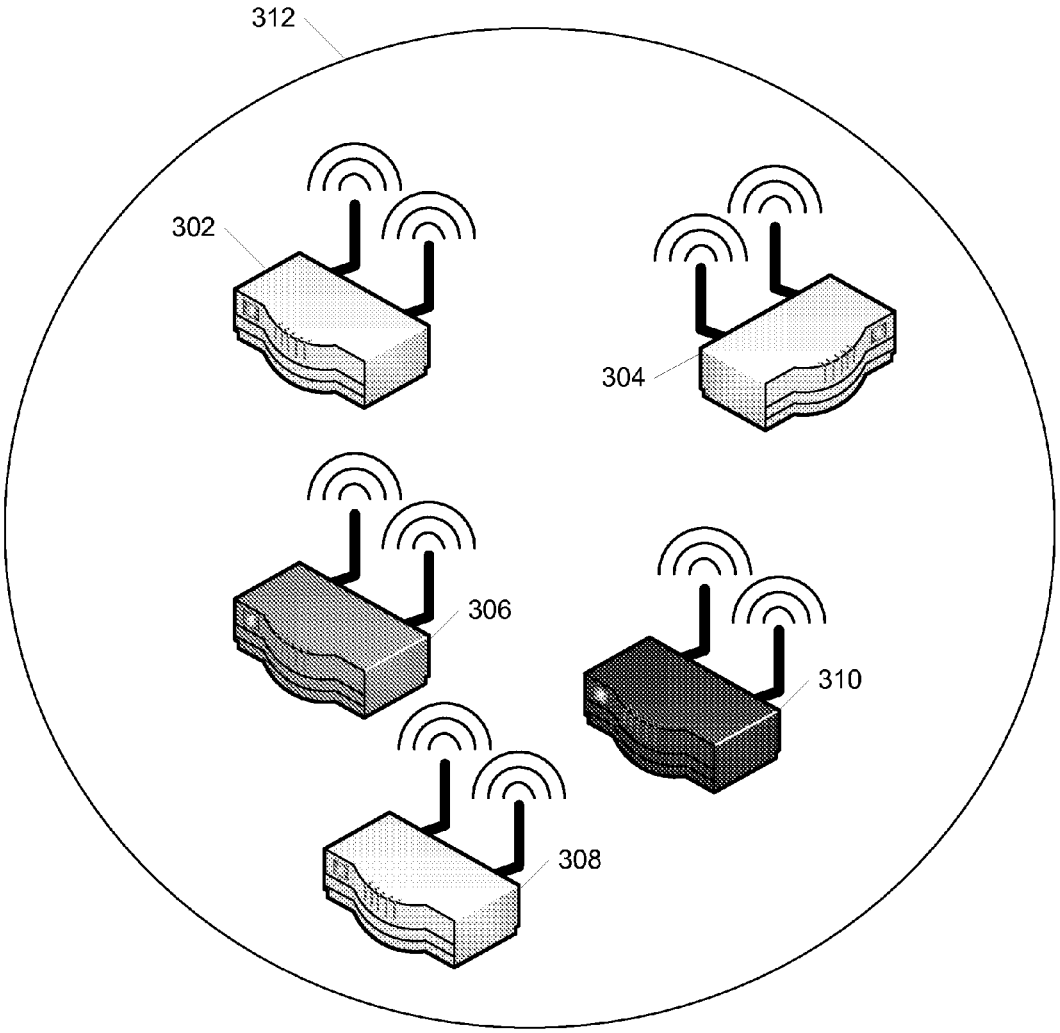


FIG. 3

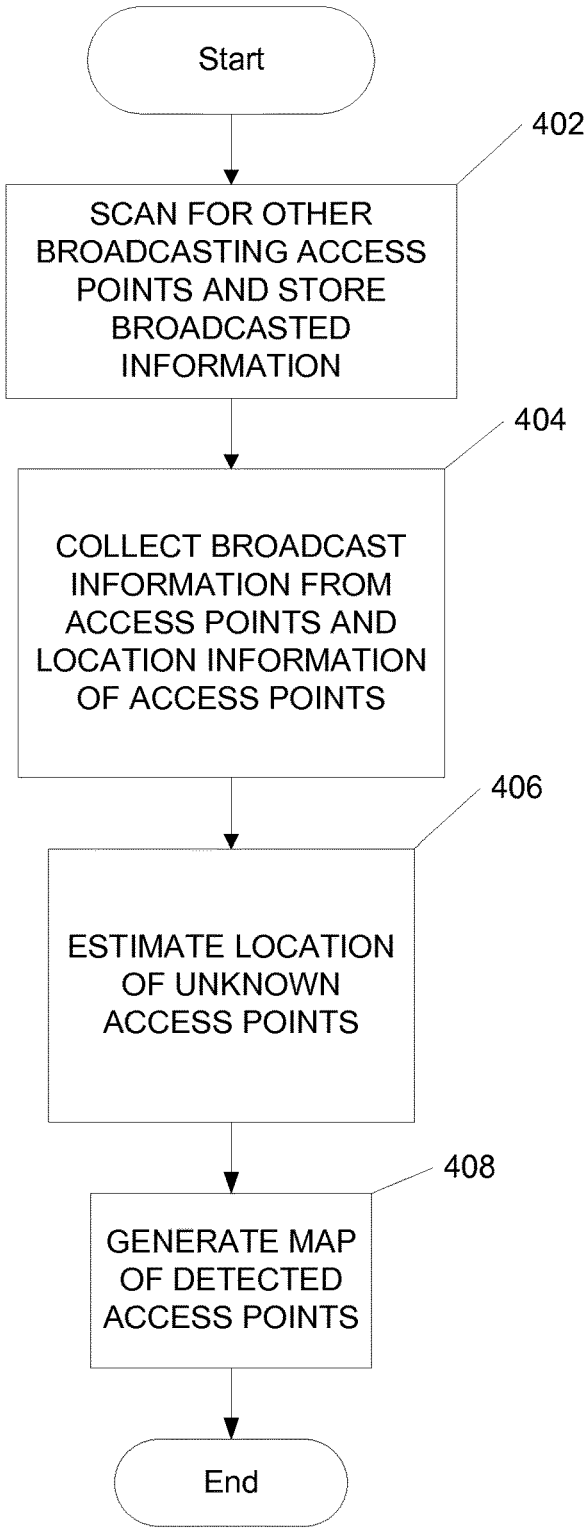

Start
402
SCAN FOR OTHER BROADCASTING ACCESS POINTS AND STORE BROADCASTED INFORMATION
404
COLLECT BROADCAST INFORMATION FROM ACCESS POINTS AND LOCATION INFORMATION OF ACCESS POINTS
406
ESTIMATE LOCATION OF UNKNOWN ACCESS POINTS
408
GENERATE MAP OF DETECTED ACCESS POINTS
End

FIG. 4

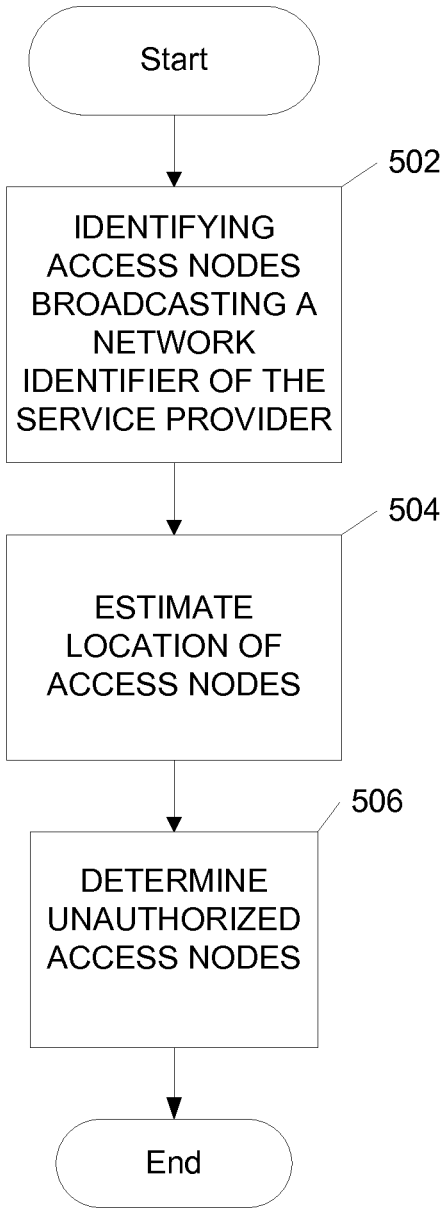

Start
502
IDENTIFYING ACCESS NODES BROADCASTING A NETWORK IDENTIFIER OF THE SERVICE PROVIDER
504
ESTIMATE LOCATION OF ACCESS NODES
506
DETERMINE UNAUTHORIZED ACCESS NODES
End

FIG. 5

DETERMINING WIRELESS COVERAGE INFORMATION USING WIRELESS ACCESS POINTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 14/259,040, filed on Apr. 22, 2014, entitled "Determining Wireless Coverage Information Using Wireless Access Points", which is related to U.S. application Ser. No. 14/259,009 filed on Apr. 22, 2014, entitled "Mapping and Bridging Wireless Networks to Provide Better Service," the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF ART

Aspects of the disclosure present methods and systems related to determining location information and coverage area information of access nodes using information collected by other access nodes and using such information, for example, for generating coverage data (e.g., maps) of a network such as a telecommunications network and for improving service based on the generated coverage data.

BACKGROUND

Access nodes can be hardware devices that provide users with access to content. For instance, access nodes may be components directly connected to physical communication strands via an interface and may include different types of components, including modems, routers, and other types of gateways. Mobile user devices such as smart phones and laptops may wirelessly access content by communicating with a gateway associated with an access node. Since each access node may have a limited coverage area, it may be desirable to generate a coverage map of access nodes in an area to be used in determining how to improve service in an area.

BRIEF SUMMARY

The following presents a simplified summary in order to provide a basic understanding of some aspects of the disclosure. This summary is not an extensive overview of the disclosure. It is not intended to identify key or critical elements of the disclosure or to delineate the scope of the disclosure. The following summary merely presents some concepts of the disclosure in a simplified form as a prelude to the more detailed description provided below.

Feature herein relate to various approaches to gathering information about access nodes serving in an area and using the information to generate a coverage map. The coverage map may be generated by detecting broadcasted signal strengths from a plurality of access nodes as detected by other access nodes. The broadcasted signal strengths can be used in combination with the location of the access nodes receiving the broadcasted signal to estimate a location of each of the plurality of access nodes. A coverage map may be generated based on the estimated locations of each of the plurality of access nodes using an effective coverage range for each access node based on the access node type. The coverage of each access node may be refined by analyzing signal data received by neighboring nodes.

Aspects of the disclosure relate to using the coverage map to identify unauthorized devices. The coverage map may be used to determine whether an access node has an unauthorized device identifier. The coverage map may be used to track movement of an access node and determine that a moved access node is outside of a predetermined distance from a last known or recorded location. Such a moved access node may be identified as unauthorized.

Aspects of the disclosure relate to using the coverage map to identify areas with a coverage density below a predetermined threshold. The coverage density may be determined based on a number of access nodes within the area.

Aspects of the disclosure may be provided in a system, an apparatus, or a computer-readable medium having computer-executable instructions to perform one or more of the process steps described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present disclosure and the advantages thereof may be acquired by referring to the following description in consideration of the accompanying drawings, in which like reference numbers indicate like features, and wherein:

FIG. **1** illustrates an example network in accordance with various aspects of the disclosure.

FIG. **2** illustrates an example of a hardware and/or software platform on which various elements described herein can be implemented in accordance with various aspects of the disclosure.

FIG. **3** illustrates an example of a plurality of wireless access nodes providing service in an area.

FIG. **4** illustrates an example of a method for generating a map of estimated access nodes.

FIG. **5** illustrates an example of a method for identifying unauthorized access nodes.

DETAILED DESCRIPTION

In the following description of the vanous embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration various embodiments in which aspects may be practiced. It is to be understood that other embodiments may be utilized and structural and functional modifications may be made without departing from the scope of the present disclosure.

FIG. **1** illustrates an example network **100**, such as a telecommunications or a content delivery network, on which many of the various features described herein may be implemented. One example may be an optical fiber network, a coaxial cable network, or a hybrid fiber/coax (HFC) distribution network. Such networks **100** may use a series of interconnected communication lines **101***a* (e.g., coaxial cables, optical fibers, wireless links, etc.) to connect access nodes **140** and other locations **102** to a central location or office (e.g., headend **103**). The central office **103** may transmit downstream information signals onto the lines **101***a* to the access nodes **140** and the other locations **102**. Each of the access nodes **140** and the other locations **102** may have a receiver used to receive and process those signals.

There may be one line **101***a* originating from the central office **103**, and it may be split a number of times to distribute the signal to various access nodes **140** and other locations **102** in the vicinity (which may be many miles) of the central office **103**. Herein, the access nodes **140** may refer to hardware modules including a device **130**, such as a modem, and a gateway interface **131**. In some aspects, an access node **140** may refer to a wireless (e.g., Wi-Fi, etc.) hotspot that

allows various user devices **116** (wireless laptops and netbooks, mobile phones, mobile televisions, personal digital assistants (PDA), etc.) to connect to the network **100** and external networks **109** for access to various content, including content found over the Internet. The device **130** may include transmitters and receivers used to communicate on the lines **101***a* and with the central office **103**. Within a given access node **140**, the device **130** may be, for example, a coaxial cable modem (for coaxial cable lines **101***a*), a fiber interface node (for fiber optic lines **101***a*), or any other desired device. Meanwhile, the gateway interface device **131** may be a computing device (e.g., a router for wireless (e.g., Wi-Fi, etc.) connectivity, etc.) that communicates with the device **130** to allow one or more wireless devices **116** to communicate with the central office **103** and other devices beyond the central office **103**, such as those devices connected to the external networks **109**. The gateway interface device **131** may also include wireless network interfaces (not shown) to provide communication signals to wireless devices **116**. The access node **140** may transmit more than one wireless network identifier (e.g., SSID). For example, the access node **140** may transmit one network identifier that is configurable by a subscriber or user and another network identifier which is only configurable by the service provider.

Meanwhile, the locations **102** may be any type of user premises, such as homes, businesses, institutions, etc. The lines **101***a* may include components not illustrated, such as splitters, filters, amplifiers, etc. to help convey the signal clearly, but in general each split introduces a bit of signal degradation. Portions of the lines **101***a* may also be implemented with fiber-optics, while other portions may be implemented with other types of lines or wireless communication paths.

The central office **103** may include an interface, such as a termination system (TS) **104**, which may be a computing device configured to manage communications between devices on the network of lines **101***a* and backend devices such as servers **105-108** (to be discussed further below). Backend devices such as servers **105-108** may be located in close proximity to one another (e.g., in the same building) and/or far apart (e.g., separate cities, countries, etc.) and may be connected to one another over various communication platforms, including over a cloud computing environment. The termination system **104** may be as specified in a standard, such as, in an example of an HFC-type network, the Data Over Cable Service Interface Specification (DOCSIS) standard, published by Cable Television Laboratories, Inc. (a.k.a. CableLabs), or it may be a similar or modified device instead. The termination system **104** may be configured to place data on one or more downstream channels or frequencies to be received by devices **130**, **110** (for example, such as modems) at the various access nodes **140** and the other locations **102**, and to receive upstream communications from the devices **130**, **110** on one or more upstream channels or frequencies. The central office **103** may also include one or more network interfaces **170**, which can permit the central office **103** to communicate with various other external networks **109**. That is, the network interface **170** may include circuitry needed to communicate with one or more external networks **109** and their corresponding devices. These external networks **109** may include, for example, networks of Internet devices, telephone networks, cellular telephone networks, fiber optic networks, local wireless networks (e.g., WiMAX), satellite networks, and any other desired network. For example, the external network **109** may include a cellular telephone network **109***a* and its corresponding cell phones **109***b*.

As noted above, the central office **103** may include a variety of servers **105-108** that may be configured to perform various functions, including providing content to the access nodes **140**, the locations **102**, cell phones **109***b*, and other devices on the external networks **109**. For example, the central office **103** may include a push notification server **105**. The push notification server **105** may generate push notifications to deliver data and/or commands to the access nodes **140** and the other locations **102** in the network **100** (or more specifically, to the devices in the access nodes **140** and the other locations **102** that are configured to detect such notifications). The central office **103** may also include a content server **106**. The content server **106** may be one or more computing devices that are configured to provide content to users at the access nodes **140** and/or the locations **102**. This content may be, for example, video on demand movies, television programs, songs, text listings, etc. The content server **106** may include software to validate user identities and entitlements, locate and retrieve requested content, encrypt the content, and initiate delivery (e.g., streaming) of the content to the requesting user and/or device.

The central office **103** may also include one or more application servers **107**. An application server **107** may be a computing device configured to offer any desired service, and may run various languages and operating systems (e.g., servlets and JSP pages running on Tomcat/MySQL, OSX, BSD, Ubuntu, Redhat, HTML5, JavaScript, AJAX and COMET). For example, an application server **107** may be responsible for collecting data such as television program listings information and generating a data download for electronic program guide listings. Another application server **107** may be responsible for monitoring user viewing habits and collecting that information for use in selecting advertisements. The application server **107** or another application server **107** may be responsible for formatting and inserting advertisements in a video stream being transmitted to access nodes **140** and other locations **102**. The application server **107** or another application server **107** may be responsible for receiving user remote control commands, and processing them to provide an intelligent remote control experience.

In addition, the central office **103** may include a server **108** (for example, a node location server) to receive data (e.g., wireless coverage data) collected by various deployed access nodes. The server **108** may analyze the collected data to generate estimate locations of access points unknown to the server **108** and to estimate coverage data (e.g., maps) of the area. In performing these functions, server **108** may also request, collect, store, and analyze various data from the access nodes **140** including system information (e.g., maps), and/or wireless (e.g., Wi-Fi) received signal strength indicator (RSSI) levels, SSID, communication channel information, and device identifier information of access points operating in the area.

An example location **102***a* (e.g., one of the locations **102**) may include an interface **120**. Similar to an access node **140**, the interface **120** may comprise a device **110**, such as a modem, which may also include transmitters and receivers used to communicate on the lines **101***a* and with the central office **103**. The device **110** may be connected to, or be a part of, a gateway interface device **111**. Similar to gateway interface device **131**, the gateway interface device **111** may be a computing device that communicates with the device **110** to allow one or more other devices at the location **102***a* to communicate with the central office **103** and other devices beyond the central office **103**, such as those devices connected to the external networks **109**. In some embodiments, the gateway interface device **111** may operate to communi-

cate with devices **112-116** located over a smaller distance than the distance between gateway interface device **131** and the user devices **116**. The gateway interface device **111** may be a set-top box (STB), digital video recorder (DVR), computer server, or any other desired computing device. The gateway interface device **111** may also include local network interfaces (not shown) to provide communication signals to the devices **112-116** at the location **102***a*, such as televisions **112**, additional STBs **113**, personal computers **114**, laptop computers **115**, wireless devices **116** (wireless laptops and netbooks, mobile phones, mobile televisions, personal digital assistants (PDAs), etc.), and any other desired devices. Examples of the local network interfaces include Multimedia Over Coax Alliance (MoCA) interfaces, Ethernet interfaces, universal serial bus (USB) interfaces, wireless interfaces (e.g., IEEE 802.11), Bluetooth interfaces, and others.

FIG. **2** illustrates general hardware and/or software elements that can be used to implement any of the various computing devices discussed herein. The computing device **200** may include one or more processors **201**, which may execute instructions of a computer program to perform any of the features described herein. The instructions may be stored in any type of computer-readable medium or memory, to configure the operation of the processor **201**. For example, instructions may be stored in a read-only memory (ROM) **202**, a random access memory (RAM) **203**, a removable media **204**, such as a Universal Serial Bus (USB) drive, compact disk (CD) or a digital versatile disk (DVD) drive, and/or a floppy disk drive, or any other desired electronic storage medium. Instructions and/or other data may also be stored in an attached (or internal) hard drive and/or a data repository **205**. The computing device **200** may include one or more output devices, such as a display **206**, and may include one or more output device controllers **207**, such as a video processor. There may also be one or more user input devices **208**, such as a remote control, keyboard, mouse, touch screen, microphone, etc. The computing device **200** may also include one or more network interfaces, such as input/output circuits **209** (e.g., a network card) to communicate with a network **210**. The input/output circuits **209** may include a network interface, such as, for example, a wired interface, wireless interface, or a combination of the two. In some embodiments, the input/output circuits **209** may include a device (e.g., a cable modem), and the network **210** may include the communication lines **101***a* discussed above, the external network **109**, an in-home network, a provider's wireless, coaxial, fiber, or hybrid fiber/coaxial distribution system (e.g., a DOCSIS network), or any other desired network.

One or more computing devices discussed herein may include some or all of the components discussed in FIG. **2**, along with additional components.

FIG. **3** shows an example of wireless access nodes within and serving a particular area. The scenario of FIG. **3** shows a plurality of wireless access nodes **302**, **304**, **306**, **308**, **310** located within an area **312** and associated with various service providers. The wireless access nodes may be the access nodes **140** shown in FIG. **1** and may be in the same or different networks **100**. The wireless access nodes may form part of a wireless local area network (WLAN) and provide access to a communication network. For example, the wireless access nodes **302**, **304**, **308** may be associated with a first service provider. The access nodes **302**, **304**, and **308** may be the access nodes **140** in network **100** connected via lines **101***a* to the central office **103**, and these nodes **302**, **304**, **308** may broadcast the same network identifier (e.g., service set identification (SSID)).

The wireless access node **306** may be associated with a second service provider and broadcast a network identifier associated with the second service provider. For example, the wireless access node **306** may be part of another network operated by a different service provider. The network may be similar to the network shown in FIG. **1**. The wireless access node **310** may be part of a network operated by a third service provider and broadcast a network identifier associated with the third service provider.

The wireless access nodes **302**, **304**, **306**, **308**, **310** may be wireless access points (e.g., wi-fi) in accordance with IEEE 802.11 standards. In order to facilitate the discovery of the access node by user devices, an access node may broadcast network information including a network identifier, network mode, and a device identifier such as a medium access control (MAC) address of the wireless access node. The user devices may receive the broadcast signal, which may be a beacon signal at a particular signal strength depending on a variety of factors including distance from the broadcasting node, interference, and surrounding environment (e.g., buildings, objects, geographical features, elevation). The received signal strength of the broadcast signal may be a received signal strength indication (RSSI). The wireless access nodes **302**, **304**, **306**, **308**, **310** may broadcast the beacon signals on the same or different communication channels such as different frequency channels. These channels may be channels defined by the IEEE 802.11 standards.

The user devices can receive the broadcast signals comprising information about the network and the device, and determine which access nodes and networks are in an area. Based on this information, a user can choose which access node and network to use. A service provider may also use the broadcast signals to determine which access nodes and networks are operating m an area. The service provider may use equipment already located within the area for this purpose.

In some aspects, the system may have knowledge of the designed coverage range of each access node model. Based on the designed coverage range, an initial coverage of the access node can be estimated. Since coverage may be affected by environmental factors, the contours of the initial coverage of the access node may be refined to reflect environmental factors (e.g., interference, fading, elevation, buildings, trees, and the like) by examining signals of the access node received by other access nodes in the area.

FIG. **4** provides an exemplary method of estimating locations of wireless access nodes using information collected by other wireless access nodes. At step **402**, the access node may scan other broadcasting access points and may store the broadcasted information. For example, in step **402**, an access node may conduct a radiofrequency (RF) survey of other access nodes broadcasting on each channel. For example, the access node **302** may scan each channel for broadcast signals from other access nodes. There may be 11 wireless communication channels (e.g., frequency channel) in use, and the access node may determine the access nodes transmitting on each communication channel and collect information about each access node including the network identifier being transmitted by each access node, the network mode, and device identifier (e.g., MAC address) of the transmitting access node. For example, from the RF survey, the access node **302** can obtain device identifiers (e.g., MAC addresses), network identifiers (e.g., SSIDs), and network mode (e.g., ad-hoc, infrastructure) of the other access nodes **304**, **306**, **308**, **310** in communication range with the access node **302**. The access node **302** may store this information in a memory to be used in combination with information

collected by other access nodes to generate a location map of access nodes in the area **312**.

At step **404**, an access node and/or a server may collect broadcast information from the access nodes and location information of the access nodes. For example, the access node **302** may receive the broadcast information (e.g., information obtained in the RF survey conducted in step **402**) from the access nodes **304**, **306**, **308**, **310**. For example, the server **108** may receive the broadcast information from the access nodes **302**, **304**, **306**, **308**, **310**. The information may be collected only from other access nodes of the same provider as the collecting device.

In some aspects, an access node may collect the information from other access nodes such as other access nodes associated with the same service provider as the collecting access node. For example, the access node **302** may identify access nodes within communication range of the access node **302** that are associated with the same service provider. The access node **302** may identify other access nodes associated with the same service provider using information gathered in the RF survey such as device identifiers and/or network identifiers. An access node may have knowledge of or access to the device identifiers (e.g., MAC addresses) of the other access nodes associated with the same service provider, for example, by receiving information about the other access nodes from the server **108**. Using the device identifiers collected in the RF survey, the access node **302** may determine that the access nodes **304**, **308** are part of the same network as the access node **302** or operated by the same service provider. According to another aspect, the access node **302** may identify the other access nodes based on the broadcasted network identifier (e.g., SSID). For example, the first service provider may use the same SSID across all of the public access nodes of the first service providers to enable customers to easily identify the first service provider's networks. After identifying other access nodes serviced by the first service providers, the access node **302** may request RF survey information from the access nodes **304**, **308** and/or location information of the access nodes **304**, **308**. The access nodes **304**, **308** may also periodically send the RF survey information to the access node **302** according to a transmission schedule. The access node **302** may retrieve location information of the access nodes **304**, **308** from a server such as the server **108**. The location information provided by server **108** may be coordinates of the physical last known location of the access nodes **304**, **308**. The last known location may be the most recently confirmed location of the access node. For example, the last known location may be an installation location provided by the installer or may be a location determined or estimated as described herein based on a RF survey. The last known location may further be manually updated by service personnel.

In some aspects, the access points may transmit the data to a server **108** in the central office **103** of the network **100**. The server **108** may be located in the central office **103** of the first service provider and may collect and store survey information received from access nodes associated with the first service provider. After scanning each channel for broadcast signals, each access node may send the server **108** the information collected during the survey. The server **108** may have access to or store information regarding the physical location of each of the access nodes. The access node **302** can also calculate the strength of the broadcast signal received by the access node **302** such as a RSSI. While steps **402-406** have been described with respect to the access node **302**, each of the access nodes may be independently conducting RF surveys and determining access points within their vicinities.

At step **406**, locations of unknown access points may be estimated based on broadcast signal properties such as the received signal strength. Using the received signal strength, each of the access nodes may estimate the distance between the access nodes and that of the access point from which the signals originated. For example, with respect to the scenario of FIG. **3**, to estimate the location of the access node **306**, each of the access nodes **302**, **304**, **308** may receive a signal transmitted from the access node **306** and estimate the distance between access node **306** and each of the access nodes **302**, **304**, **308**. During service provisioning of the access nodes **302**, **304**, **308**, the first service provider may record device locations of each of the access nodes **302**, **304**, **308**, for example, using a geographic coordinate system (e.g., latitude and longitude, global position system (GPS) coordinates, etc.). Based on the locations of the access nodes **302**, **304**, **308** and the strength of the signal from the access node **306** received at each of the access nodes **302**, **304**, **308** a location of the access node **306** may be estimated based on signal triangulation. For example, by analyzing the signal strengths received by each of the access nodes **302**, **304**, **308** and the locations of the access nodes **302**, **304**, **308**, an estimated location of the access node **306** may be determined. The estimated location may be a range of locations in which the node **306** may be located. An estimate of the location of access node **310** may also be determined in a manner similar to estimating the location of the access node **306**.

At step **408**, a map may be generated of the detected access points within the area **312** based on the known locations of the access nodes **302**, **306**, **308** and the estimated locations of the access node **306** and the access node **310**. The generated map may be stored with a timestamp of the data collection time or the time at which the map was generated. The map may be updated periodically by scanning each communication channel and generating an updated map.

Based on the exemplary method of FIG. **4**, a determination can be made of the types, number, and coverage of access nodes within a particular area using access nodes located within or near the area.

In some aspects, the computing device may have geographic coordinates and device information stored for access nodes in an area. Based on the device information, an effective range of the device may be known. Using access node location information estimated as described herein or stored locations of devices, a coverage map may be generated with each access node having a range equal to its effective range. Since a variety of factors may affect actual coverage (e.g., interference, geography, elevation, buildings, trees), the coverage of an access node may be refined using the captured signal strengths (e.g., RSSI) of the devices. For example, based on the effective range of the first access node, a request may be sent to other access nodes within the effective range of the access node to determine whether the other access nodes can actually receive signals from the first access node. If the other access nodes can receive signals from the first access node, the access node may further respond with the received signal strength (e.g. RSSI) of the first access node. By querying access nodes within the effective range of the first access node, the coverage of the first access node can be refined based on whether other access nodes can receive signals and the signal strength of the signal received by the other access nodes.

According to another aspect, the coverage map may identify the central office **103** to which each access node **120**, **140** is connected. More than one central office **103** may be serving nodes in a particular area. A server (e.g., server **108**) may receive coverage information gathered by the access nodes connected to same central office **103** as the server **108**. For the access nodes that are not connected to the same central office **103** as the server **108**, the server **108** may transmit a request to other central offices requesting information on whether the other central offices are connected to certain access nodes, which may be identified based on a device identifier. The request may be transmitted via various paths including through connections between various central offices.

Based on the generated map and estimated location information of access nodes associated with a different provider, a service provider can analyze the location information to determine weak spots in the service provider's coverage and the coverage of other service providers. The illustrative method of FIG. **4** is also beneficial since a service provider may use access nodes already deployed within an area to estimate the deployment of access nodes in the area by the service provider and other service providers. A service provider may also be better able to monitor their networks for unauthorized devices by having knowledge of all access nodes providing service in an area.

FIG. **5** illustrates a flowchart of a method of identifying and locating unauthorized access points. At step **502**, the access nodes or a computing device of a service provider may identify the access nodes broadcasting a network identifier (e.g., SSID) associated with the service provider from a coverage map. Unauthorized devices may be devices that broadcast a network identifier associated with the service provider but is not a device authorized to broadcast the service provider's network identifier according to the device's device identifier. An unauthorized device may be a device located outside of an authorized area. For example, a server associated with the service provider may store a last known or recorded location of the device. If an updated location of the device is obtained that is a specific distance away from the last known or recorded location of the device, the device may be identified as unauthorized.

A computing device can determine neighboring access nodes of the potentially unauthorized device that may be able to receive the broadcast signal of the potentially unauthorized device based on the coverage map. As discussed above, access nodes may continuously broadcast network information to enable wireless devices to discover the access node and connect to the access node to access a communication network. The broadcasted information may include a network identifier (e.g., SSID) and the broadcasting device's identifier (e.g., MAC address). The network identifier may be a network identifier broadcasted by more than one access node. The network identifier may also be a unique network identifier associated with a particular location or subscriber. The service provider can use access nodes associated with the service provider to detect all access points that are operating within a vicinity of service provider's access nodes including the service providers of other access nodes. The service provider can receive the broadcast signal information from its associated access nodes and check whether each access node broadcasting a network identifier associated with the service provider is authorized to do so. For example, the service provider may maintain a database of deployed access nodes and information of the deployed access nodes such as authorized SSIDs, location information, device identification information (MAC address, serial number, etc.).

At step **504**, the system can estimate locations of access nodes broadcasting a network identifier associated with the service provider using aspects described herein. At step **506**, the service provider can determine any unauthorized access nodes. For example, the service provider can determine whether a device broadcasting the service provider's network identifier (e.g., SSID) is an authorized device. This may be performed, for example, by determining whether the device's identification information (e.g., MAC address, serial number) is stored in the database as a device authorized to broadcast the service provider's SSID or whether the device's location as estimated based on data gathered from neighboring nodes is within a predetermined distance or area of the recorded location of the device. Devices greater than the predetermined distance away from the recorded location or outside of the predetermined area may be flagged as unauthorized devices. The database may also contain information regarding or associated with devices of other service providers who are authorized to use the service provider's SSID.

In response to determining that the device is an unauthorized device, the account associated with the unauthorized device may be flagged, the information associated with the account may be reconfirmed, or service to the unauthorized device may be discontinued.

In response to determining that a particular device is not authorized to broadcast the network identifier that the particular device is broadcasting, the system can estimate the location of the unauthorized device based on the signal being broadcasted by the device according to aspects of the disclosure described herein such as the method shown in FIG. **4**.

Using a coverage map generated for example from the method described with respect to FIG. **4**, the service provider is able to obtain an overall picture of coverage by various service providers in areas where the service provider has nodes deployed. Within detection ranges of a service provider's nodes, the service provider can obtain a picture of its own network coverage as well as that of other service providers. For example, the service provider can analyze the density of access nodes in different areas as well as received signal strengths of the access nodes. The service provider may be able to determine areas where signal strengths are below an acceptable threshold.

A network **100** may store system information (e.g., maps, device information, subscriber account information, coverage information) in any database associated with the central office **103**. System information may depict, for example, the communication backhaul of the network **100**. The server **108** may use system information (e.g., maps of the network **100**) to pinpoint possible locations of an access node **140**. In some aspects, the server **108** may use wireless (e.g., Wi-Fi) information to determine the distance between an access node **140** from which a wireless signal is being transmitted and another access node. The server **108** may determine this distance by collecting wireless information (e.g., Wi-Fi RSSI levels) from an access node **140**, other neighboring access nodes **140**, and/or the user devices **116** connecting to the access node **140**.

Although the subject matter disclosed herein has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above.

Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A method comprising:

sending, by a first access node and to a second access node, a first signal comprising a request for an indication of a strength of the first signal;

receiving, by the first access node and from the second access node, the indication of the strength of the first signal;

generating, based on the indication of the strength of the first signal, a geographical map comprising a location of the first access node and an estimated coverage area of the first access node;

receiving, by the first access node, from a third access node, and via the second access node, an indication of a strength of a second signal, wherein the second signal was sent by the second access node and received by the third access node; and

updating, based on the indication of the strength of the second signal, and estimated location of the second access node and an estimated coverage area of the second access node on the geographical map.

2. The method of claim 1, further comprising:

sending, by the first access node and to the third access node, a third signal comprising a request for an indication of a strength of the third signal;

receiving, by the first access node and from the third access node, an indication of the strength of the third signal; and

updating, by the first access node and based on the indication of the strength of the third signal, the estimated location of the second access node and the estimated coverage area of the second access node.

3. The method of claim 1, further comprising:

receiving, by the first access node and from the second access node, a third signal comprising a request for an indication of a strength of the third signal;

determining, by the first access node and based on the second signal, the strength of the third signal; and

sending, by the first access node and to the second access node, the indication of the strength of the third signal.

4. The method of claim 1, further comprising:

for each channel of a plurality of channels, scanning, by the first access node, the channel to determine a corresponding set of one or more access nodes that are transmitting over the channel.

5. The method of claim 1, further comprising:

receiving, by the first access node and from a fourth access node, a network identifier associated with the fourth access node;

determining, based on a plurality of coverage areas of a plurality of access nodes on the geographical map, one or more access nodes, of the plurality of access nodes, able to receive a signal from the fourth access node; and

estimating, based on one or more geographic locations of the one or more access nodes on the geographical map, a geographic location of the fourth access node.

6. The method of claim 5, further comprising:

determining, based on the estimated geographic location of the fourth access node, whether the fourth access node is located within a particular area; and

in response to determining that the fourth access node is not located within the particular area, storing an indication that the fourth access node is an unauthorized device.

7. The method of claim 6, further comprising:

determining, based on a last recorded geographic location of the fourth access node and a threshold distance, the particular area.

8. A method comprising:

receiving, by a first access node and from a third access node, an indication of a strength of a first signal that was sent from a second access node and to the third access node, wherein the indication of the strength of the first signal was generated by the third access node;

generating, based on the indication of the strength of the first signal, a geographical map comprising an estimated coverage area of the second access node;

determining, based on an estimated geographic location of the second access node, whether the second access node is located within a particular area; and

in response to determining that the second access node is not located within the particular area, storing an indication that the second access node is an unauthorized device.

9. The method of claim 8, further comprising:

sending, by the first access node and to the second access node, a second signal comprising a request for an indication of a strength of the second signal;

receiving, by the first access node and from the second access node, the indication of the strength of the second signal; and

updating, based on the indication of the strength of the second signal, an estimated coverage area of the first access node on the geographical map.

10. The method of claim 9, further comprising:

sending, by the first access node and to the third access node, a third signal comprising a request for an indication of a strength of the third signal;

receiving, by the first access node and from the third access node, the indication of the strength of the third signal; and

updating, based on the indication of the strength of the third signal, the estimated coverage area of the first access node on the geographical map.

11. The method of claim 8, further comprising:

receiving, by the first access node and from the third access node, a second signal comprising a request for an indication of a strength of the second signal;

determining, by the first access node and based on the second signal, the strength of the second signal; and

sending, by the first access node and to the third access node, the indication of the strength of the second signal.

12. The method of claim 8, further comprising:

for each channel of a plurality of channels, scanning, by the first access node, the channel to determine a corresponding set of one or more access nodes that are transmitting over the channel.

13. The method of claim 8, further comprising:

receiving, by the first access node and from the second access node, a network identifier associated with the second access node;

determining, based on a plurality of coverage areas of a plurality of access nodes on the geographical map, one or more access nodes, of the plurality of access nodes, able to receive a signal from the second access node; and

estimating, based on one or more geographic locations of the one or more access nodes on the geographical map, a geographic location of the second access node.

14. The method of claim 8, further comprising:

determining, based on a last recorded geographic location of the second access node and a threshold distance, the particular area.

15. A system comprising:

a first access node configured to:

send, to a second access node, a first signal comprising a request for an indication of a strength of the first signal;

receive, from the second access node, the indication of the strength of the first signal; and

generate, based on the indication of the strength of the first signal, a geographical map comprising a location of the first access node and an estimated coverage area of the first access node;

the second access node, wherein the second access node is configured to:

receive, from the first access node, the first signal;

determine the strength of the first signal;

send, to the first access node, the indication of the strength of the first signal;

send, to a third access node a second signal comprising a request for an indication of a strength of the second signal;

receive, from the third access node, the indication of the strength of the second signal; and

send, to the first access node, the indication of the strength of the second signal; and

the third access node wherein the third access node is configured to:

receive, from the second access node the second signal;

determine, based on the second signal, the strength of the second signal; and

send, to the second access node, the indication of the strength of the second signal.

16. The system of claim 15, wherein the first access node is configured to:

estimate, using the geographical map and based on the indication of the strength of the second signal, a geographic location of the third access node;

determine, based on the estimated geographic location of the third access node, whether the third access node is located within a particular area; and

in response to determining that the third access node is not located within the particular area, storing an indication that the third access node is an unauthorized device.

17. The system of claim 15, further comprising:

a server associated with a service provider,

wherein the first access node is configured to send, to the server, results of a signal survey performed by the first access node, and

wherein the second access node is configured to send, to the server, results of a signal survey performed by the second access node.

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